CHAPTER-18
TECHNICAL EFFICIENCY BANKS: AN EMPIRICAL ANALYSIS

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ABSTRACT

This study examines the technical efficiency of banking sector and its affecting factors in India using a panel data during 2005–2020. It used log-linear regression model under a stochastic frontier production function approach. It considers 47 scheduled banks (18-public sector, 13-private sector and 16-foreign sector). The technical efficiency is estimated as assuming that return-on-investment and return-on-advances of banks are the important outputs. Fixed assets, total assets, total employees, total deposits, return on equity and capital adequacy rate are vital inputs to increase the performance and efficiency of banks. The empirical results show that return-on-investment of banks increases as increase in fixed assets, total assets, total employees, total deposits, total foreign currency assets, return on equity and cost of funds. Return-on-advances of banks is likely to increase as increase in total employees, total deposits, ratio of non-interest income to total assets, cost of funds and capital adequacy rate. The estimated technical efficiency of selected banks show that there is significant variation in technical efficiency across banks. Indian bank and Indian Overseas Bank have highest technical efficiency among the public sector banks in India. Syndicate bank and UCO banks have a lowest technical efficiency in Indian public sector banks. Nainital bank, Lakshmi Vilas Bank, Kotak Mahindra Bank, ICICI Banks and HDFC Banks have highest technical efficiency among the private sector banks. The technical efficiency of other banks in private sector is seemed in efficient. Bank of America, Bank of Bahrain & Kuwait, Federal Bank, Mashreq Bank, Mizuho Bank and MUFG Bank have the better technical efficiency among the foreign sector banks. Technical efficiency of banks is positively associated with fixed assets, total foreign currency assets, ratio of demand-saving

deposits, ratio of non-interest income to total assets, capital adequacy rate and investment deposit ratio. Thus, Indian banks should focus on abovementioned variables to increase their technical efficiency.

Keywords: Technical Efficiency; Banking Sector; Return-on-investment, Return-on-Advances; India.

18.1 INTRODUCTION

Banking industry has a significant role to increase the socio-economic development of nation (Hamid et al., 2017). Financial and banking institutions provide several facilities like loans to individual and business community. These institutions are also accepting the deposits from individual and business community, and provide them interest (as an income) on their deposits. Furthermore, banking institutions provides the loans to the all sectors such as agriculture, industry and services in a country. Also, banking institutions facilitates several other policies implementing by governments for common citizens in a country. As banking sector provides the short-term and long-term loans to public and accepts the deposit from the common citizen in a country (Kumari, 2019; Hafsal et al., 2020). Accordingly, banking industry has an effective contribution to maintain the economic development of a country (Singh and Fida, 2015; Hamid et al., 2017; Tanwar et al., 2020). In India, financial sector is well developed and it has an important contribution to increase socio-economic activities of people (Gupta et al., 2008). As banking sector of India has significant size, thus, it has a vital impact on Indian economy (Singh and Malik, 2018). As India has a largest working population, thus, the demand of banking services is increased in India (Tanwar et al., 2020). There are many other reasons such as technological interference, mobile banking, online banking which also increased the demand of banking services in India (Tanwar et al., 2020). Subsequently, Indian banking sector is one among the most growing business countries (Singh and Malik, 2018).

At present Government of India has converted or most public sector banks in private sector or merged with other banks due to several reasons such as rising non-performing asset, decreasing technical efficiency of public sector bank, decreasing employees and others. Public sectors banks are unbale to maintain financial activities in rural area. Therefore, profit of public sector banks is

decreased over period of time. The performance of foreign bank, private sector bank and foreign bank for the 2019 and 2020 is given in Table 1. It infers that public sector banks have the larger contribution in investment amount, government securities, advances, fixed assets, total assts, income on investment, Total of Deposits, Total of Borrowings, Total of Loans and Advances, and Total Employees in all scheduled commercial banks. Thus, it shows that public sector banks have an effective contribution to maintain the financial activities in India. However, public sector banks have larger amount of non-performing assets among the private and foreign sector banks which increase the additional burden on public sector bank to sustain their financial activities.

Table 18.1: Brief summary of public, private and foreign bank in India in 2019 and 2020

Banks	All Scheduled Commercial Banks		Foreign Banks		Private Sector Banks		Public Sector Banks	
Year	2019	2020	2019	2020	2019	2020	2019	2020
Investments	4322463.57	4689841.57	383432.68	431276.74	1222044.98	1293031.17	2702033.24	2940636.33
Investments in India	4188559.33	4559520.33	368069.21	408004.67	1196512.85	1275925.63	2609024.59	2850692.70
Investments outside India	133904.24	130321.24	15363.47	23272.07	25532.13	17105.54	93008.65	89943.63
Government securities	63472.94	68200.67	13803.06	21561.96	18699.45	9239.51	30970.44	37399.20
Advances	9676182.55	10301914.47	396725.90	428071.95	3327328.07	3625154.47	5892667.34	6158111.98
Advances in India	8979406.24	9522611.80	396725.90	428071.95	3162812.72	3464131.86	5360406.38	5539831.92
Fixed Assets	149136.93	150727.84	4425.67	4128.78	36141.69	38242.63	107318.44	106506.67
Total Assets	16601045.12	18014874.90	1056374.71	1265304.23	5297936.79	5832139.13	10163225.99	10783018.05
Income on investments	298355.39	306840.35	21697.47	27339.88	81220.11	82899.25	194496.36	195100.25
Net profit (loss) on sale of investments	14161.96	38990.68	96.86	1322.66	4282.17	12691.07	9741.30	24746.90
Net profit (loss) on revaluation of investments	-2257.60	-830.02	-174.13	279.10	41.71	-986.61	-2125.18	-122.50

Net profit (loss) on sale of land and other assets	577.79	388.09	53.70	310.10	-22.32	28.83	549.28	53.55
NPA	300269.87	259888.63	1241.58	1879.45	68084.01	83651.42	230619.53	173739.17
Net Profit	-23397.39	10910.69	14507.83	16180.37	27621.01	19111.37	-66608.01	-26015.00
Total of Deposits	12885938.19	13974009.11	581234.71	684288.47	376931.22	415795.50	848621.55	904841.34
Total of Borrowings	1703402.22	1680750.00	151216.27	127968.62	76920.52	82063.74	761612.21	702133.38
Total of Loans and Advances	9708749.42	10341046.89	396627.77	427972.35	332605.65	362398.05	592660.77	619851.42
Total Employees	1364285	1466213	23218	23582	477709	554685	807577	790687

Source: RBI (Government of India).

As banking sectors have a greater contribution to sustain the money flow in country, thus, it greatly contributes towards socio-economic development of people. Accordingly, there is essential to measure the performance of banking sector to resolve the existing issues of this sector in a nation. Performance of banking sector can be observed through efficiency, profitability and competition (Kumari, 2019). Measurement of technical efficiency of banking sector is essential to increase their productivity and profitability. Measurement of technical efficiency of a banking industry is also useful to increase its the performance in future. As efficiency measure the contribution of various inputs in output in banking industries. It also estimates the efficiency of system whether available inputs have appropriate contribution to achieve maximum output in banking industry (Singh and Gupta, 2013; Singh and Malik, 2018).

The performance of private and foreign banks is increasing in India (Singh and Gupta, 2013). Performance based assessment of banking industry is useful for policy makers to take a further policy action in banking sector (Gupta et al., 2008). Performance of a banking industry can be estimated through productivity and efficiency (Gupta et al., 2008). Productivity is associated with marginal contribution of inputs in output in a specific bank (Gupta et al., 2008). Efficiency is a best measurement of performance and productivity of banking sector (Singh and Fida, 2015;

Singh and Malik, 2018). Efficiency shows the ratio of output and input of any production unit in a country. It is also conducive to increase the further growth of banking sector (Gupta et al., 2008). Since, there is a high uncertainly in activities of banking sector due to several reasons. Hence, the performance of banking sector must be measured at regular basis.

In India, several studies have estimated the technical efficiency of public, private and foreign sector banks in different aspects using stochastic frontier production function model and data envelopment analysis (Singh and Malik, 2018). Previous studies have analysis the variation on technical efficiency of banks in different time span (Singh and Malik, 2018). Most studied argued that overall technical efficiency of public sector bank are found lower as compared to private sector banks (Singh and Malik, 2018). However, the technical efficiency of few public sector like SBI, UCO and Punjab National Bank are appeared higher among the other public sector bank (Gupta et al., 2008; Singh and Malik, 2018). Few studied have noticed that private sector banks have higher productivity as compared to public sector bank (Narwal and Pathneja, 2015). Based on aforesaid literature, it can be argued that most studied have estimated the technical efficiency of banking sector in India. However, previous studied could make the cross comparison of technical efficiency among the public, private and foreign sector banks in India. Therefore, the present study tries to make the comparison in technical efficiency of public sector, private sector and foreign sector in India during 2005-2020.

The present study is an attempt to assess the answers on following research questions:

- How technical efficiency of Indian banking sector is varied over period of time?
- What are major variables which have significant influence of technical efficiency of banking sectors in India?
- How and why technical efficiency is varied across public, private and foreign banks in India?
- Which banks have higher technical efficiency among the public, private and foreign sector banks in India?
- How banking sector can increase the technical efficiency in India?
- With regards to aforementioned research questions, the present study is achieved following objectives:

- To examine the technical efficiency of public, private and foreign sectors banks in India.
- To assess the technical efficiency affecting factors of public, private and foreign sectors banks in Indian banking sector.

18.2 REVIEW OF LITERATURE

Technical efficiency of banking sector is estimated by several researchers in different economies using various methods (Zhao et al., 2021). For instance, De (2004) have examined the technical efficiency of banking industry in India using a stochastic frontier production function model. This study claimed that efficiency of banking industry could not improve after liberalization in India. While foreign banks have higher efficiency as compared to Indian banking industry. Furthermore, this study indicates that more that 70% of banks have efficiency and 14 banks out of 18 banks have the efficiency, thus, results show that Indian banks have high diversity in technical efficiency across public, private and foreign banks in India. Gupta et al. (2008) estimated the productivity efficiency of banking sector in India using non-parametric frontier method. It infers that SBI and its groups have highest efficiency among the other private and public sector banks in India. It also shows that productive efficiency of the banking sector is increased during 1999-2003.

Singh and Gupta (2013) provided the comparison on technical efficiency of top banks in India using data envelopment analysis. It reported that level of input and output variables in efficiency measurement have changed significantly during this period and banks could improve their efficiency. It suggested that advance, investment are the important output variables, whereas operating cost, fixed assets and capital are the crucial input. Roy (2014) have estimated the efficiency of Indian banking sector using Data Envelopment Analysis. This study claimed that inappropriate size allocation is responsible for inefficiency of Indian banking sector. Narwal and Pathneja (2015) have assessed the productivity and profitability of banking system in India using a data enveloped data analysis. This study used Total factor productivity, efficiency change, technological change, and return on average assets as dependent variables. Spread to total average assets, diversification, and share of bank in total deposits as independent variables. The empirical findings of this study clearly indicate that that private sector banks have more productivity than public sector bank.

Kumar and Gulati (2018) have examined the technical efficiency of 27 public sector banks in India using data envelopment analysis. It included cross-sectional data of 27 public sector banks for a financial year (i.e., 2004 – 2005). The empirical results show that only seven banks are seemed efficient. Accordingly, it indicates that most public sector banks do not have perfect efficiency. This study is also claimed that exposure to off-balance sheet activities, staff productivity, market share and size are appeared most important variables that have significant impact on technical efficiency of banking sector in India. Singh and Malik (2018) estimated the technical efficiency and its affecting factors of public and private sector bank in India using a data envelopment analysis. The results of the study claimed that there is a significant variation in technical efficiency of public and private sector in Indian banking system. UCO, SBI and Punjab National Bank have the better technical efficiency among the public sector banks and Jammu & Kashmir and Nainital Bank are seemed most leading bank among the private sector bank in India. Also, profitability, bank size and gross domestic product and productivity of employees are seemed most influencing of technical efficiency of banking sector in India. Deb (2019) have examined the impact of bank size on efficiency of commercial banks in India using a Data Envelopment Analysis. It observed that total assets and number of branches have a positive impact on efficiency of commercial banks in India. Tanwar et al. (2020) have estimate the overall efficiency of banking industry in India using a data envelopment analysis and provide the comparison of efficiency among the public, private and foreign banks. It observed that most banks have low efficiency, there is significant variation in technical efficiency across banks. This study argued that performance of banks depends upon input-output variable.

18.3 RESEARCH METHODS AND MATERIAL

18.3.1 Selection of Banks

This study compiles the panel data of concerned variables for selected banks in public, private and foreign sector. For this, it considered the data for respective variables during 2005 – 2020. Thus, this study includes only those banks which have the data for useful variables. Accordingly, it compromises 47 banks (18 – public sector, 13 – private sector and 16 – foreign sector) in India. The list of selected banks is given in Table 2. The required data for selected banks is derived from the official website of Reserve Banks of India (Government of India).

Table 18.2: List of selected banks in public, private and foreign sector

Public Sector	Private Sector	Foreign Sector
Allahabad Bank, Andhra Bank, Bank of Baroda, Bank of India, Bank of Maharashtra, Canara Bank, Central Bank of India, Corporation Bank, Indian Bank, Indian Overseas Bank, Oriental Bank of Commerce, Punjab And Sind Bank, Punjab National Bank, State Bank of India, Syndicate Bank, UCO Bank, Union Bank of India, United Bank of India	Axis Bank Limited, City Union Bank Limited, DCB Bank Limited, Federal Bank Ltd, HDFC Bank Ltd., ICICI Bank Limited, IndusInd Bank Ltd., Jammu & Kashmir Bank Ltd., Karnataka Bank Ltd., Kotak Mahindra Bank Ltd., Lakshmi Vilas Bank Ltd., Nainital Bank Ltd., Tamandu Mercantile Bank Ltd., Yes Bank Ltd.	Bank of America National Association, Bank of Bahrain & Kuwait B.S.C., Bank of Ceylon, Bank of Nova Scotia, Barclays Bank PlC, BNP Paribas, Citibank N.A., CTBC Bank Co. Ltd., DBS Bank India Ltd., Deutsche Bank Ag, Mashreq Bank PSC, Mizuho Bank Ltd., MUFG Bank Ltd., Shinhan Bank, Standard Chartered Bank

18.3.2 Measurement of Technical Efficiency

Data Envelopment Analysis (DAE) and stochastic frontier production approach (SFPA) are the main methods which can be used to examine the technical efficiency of a production units of different sectors (De, 2004; Gupta et al., 2008; Singh and Gupta, 2013; Singh and Gupta, 2013; Singh et al., 2017; Singh et al., 2018; Singh et al., 2019; Kumari, 2019; Singh et al., 2019a; Tanwar et al., 2020; Zhao et al., 2021). Technical efficiency can be measured in two ways i.e., input-oriented and output oriented (Singh and Gupta, 2013). Input-oriented efficiency is useful to reduce quantity of inputs to produce goods and services, while, output-oriented efficiency is useful to increase the output as using the available inputs in production activities (Singh and Gupta, 2013; Singh et al., 2018). Technical efficiency is useful to assess the ability of a production unit to use minimum quantity of inputs to obtain maximum output (Singh et al., 2019). Aforesaid techniques can be used in parametric and non-parametric conditions (Singh and Malik, 2018). Accordingly, the technique requires minimum assumptions (Singh and Malik, 2018). Data envelopment analysis is a mathematical technique to examine the performance of a

set of peer entities which is useful to converts various inputs into output (Singh and Malik, 2018; Tanwar et al., 2020). Data envelopment approach is also useful to make a decision to achieve optimal ratio between input and output (Singh and Malik, 2018). Singh and Gupta (2013); Singh and Malik (2018) have claimed that data envelopment analysis is relatively more important to estimate the efficiency of banking sector. Hence, aforesaid methods do not any assumptions to analysis the data.

As stochastic frontier production approach is helpful to estimate the technical efficiency and regression coefficients of independent variables (inputs) with dependent variables (output) (Singh et al., 2017; Singh et al., 2019; Singh et al., 2019a; Singh et al., 2020). Thus, stochastic frontier production function approach is used to estimate the technical efficiency of banking sector in India (Roy, 2014). Previous studies also used this technique to examine the technical efficiency of banking sector in different countries. The stochastic production function approach is developed as (Singh et al., 2019):

$$Y_i = f(X_i, \beta)\ exp\ (e)_i \quad (1)$$

$$Y_i = f(X_i, \beta)\ exp\ (v_i - u_i) \quad (2)$$

Here, Y_i is the dependent variable (output) of i^{th} entity of a production unit, X is vector of inputs; β is the vector of regression coefficient of associated inputs (Singh et al., 2018; Singh et al., 2019). e is the random error tern that is combination of v_i and u_i. In the abovementioned equation, u_i is one-sided inefficiency, v_i and u_i are normally distributed for different entities (Singh et al., 2019).

As per the aforementioned estimation, technical efficiency (TE) is measured as:

$$(TE)_i = exp\ (-u)_i \quad (3)$$

Here, TE_i is technical efficiency of i^{th} entities and u_i is calculated from equation (2). The value of *TE* lie between 0 to 1 (Singh et al., 2018; Singh et al., 2019). If the value of *TE* is 1 for a specific firm, then it infers that the firm is technically efficient (Singh et al., 2019a). Furthermore, 1 – *TE* measure the efficiency gap actual production and optimal possible production that may be obtain through maintain the inputs and outputs in production entities (Singh et al., 2018; Singh et al., 2019).

18.3.3 Explanation of Variables

As stochastic frontier production function approach and data envelopment analysis techniques are effective to measure the efficiency of multiple inputs and multiple outputs in production units (Singh et al., 2018). Previous studies have used different inputs such as net worth, interest expenses, borrowings, operating expenses, number of employees, number of bank branch, capital-fixed asset, net fixed asset, equity and net performing asset (Mukherjee et al., 2002; Sathya, 2003; Das and Ghosh, 2009; Jagwani, 2012; Singh and Gupta, 2013). Accordingly, prior studies have used different variables like deposits, interest income, net profits, advances, non-interest income, interest payments, loans and advances and investment as output (Mukherjee et al., 2002; Sathya, 2003; Das and Ghosh, 2009; Jagwani, 2012; Singh and Gupta, 2013). Furthermore, Golany and Storbeck (1999) have examined the operational efficiency in USA using data envelopment analysis. This study is used labour and marketing as input variables, and loans, deposits, number of accounts per customer and satisfaction as output variables. Ho and Zhu (2004) have examined the performance of commercial bank in Taiwan. This study is considered assets, employees, branches and capital stock as inputs, while sales and deposits are used as output variables. Howland and Rowse (2006) have estimate the efficiency of banking sector in Canada using DAE method. This study is considered non sales, sales FTE, loans, deposits, average number of product and customer loyalty as inputs and output variables. Singh and Gupta (2013) have used various inputs such as capital, fixed assets, interest expenses, total borrowing, total deposits, total liabilities and operating cost, while, advances, investments, net profit and total revenue are used as output variables to estimate the efficiency of 5 public sector bank, 5 private and 5 foreign banks in India.

Kordrostami et al. (2016) have used different variables as inputs (i.e., employees and expenses) and outputs (i.e., deposits and loans) to assess the performance of banking system in Iran. Desta (2016) have examined the performance of African banks using different input and output variables such as: interest expense, non-interest expense, transaction deposit, non-transaction deposit, gross loan, earning assets, interest income and non-interest income. Singh and Malik (2018) have considered net fixed assets, number of full-time staff and loanable fund as inputs variables, while, non-interest income and net interest income as output variables to examine the technical efficiency of Indian banking sector. Further, this study is used ratio of net NPA to advance, return on assets, business per employee, real gross domestic product and total asset in regression analysis. Ofori-Sasu et al. (2019) have also estimate the technical efficiency of

banking sector in Ghana. This study is used total cost and total deposits as input variables, and total loans and other earnings are used as output variables. Wanke (2019) have assessed the efficiency of banking sector. This study is used net loans, total earning assets, non-earning assets, loss provisional costs as inputs, and net interest margin, equity and income as output variables. Zhao et al. (2019) have assessed the efficiency of banking sector in China using input (i.e., interest payments, employees' salaries, fixed assets) and output (i.e., net interest margin, equity and income) variables. Deb (2019) have used number of employees, equity capital and deposits as inputs, advances, investments and non-interest income as outputs to examine the technical efficiency of commercial banks in India. Aforementioned literature clearly indicates that there is no uniformity in selection of input and output variables in analysing the technical efficiency and its affecting factors in Indian banking sector.

18.3.4 Empirical Model for Addressing the Technical Efficiency Affecting Factors

Previous studies have used different indicators such as net profit, net return on assets, business per employees, operating profit per employee and capital adequacy to estimate the performance of the banking sector in India (Roy, 2014; Singh and Malik, 2018). Singh and Fida (2015) have used bank size, capital adequacy ratio, operating profit, total assets and profitability are used to estimate the technical efficiency of banking sector in Oman. Gupta et al. (2008) have used business per employees as a proxy for productivity, capital adequacy ratio as a proxy for regulatory, net NPA per net advances as proxy for asset quality, operating profit per total assets as proxy for profitability and total asset of the bank a proxy for size of bank to estimate the performance of banking sector in India. It seemed that prior studies have different variables to examine the technical efficiency of banking sectors. Therefore, in this study 36 most relevant variables of selected banks are used as dependent and independent variables to estimate the technical efficiency and it's affecting factors in Indian banking sector. However, all variables could not use in empirical models due to existence of high correlation among the variables. Therefore, these variables are also segregated in input and output variables as per the existing studies (Refer to Table: 3).

Table 18.3: List of inputs and output variables

Inputs	Outputs

Variables	Unit	Variables	Unit
Investments	in Crore	Advances	in Crore
Fixed Assets	in Crore	Income on investments	in Crore
Total Assets	in Crore	Interest Earned Total	in Crore
NPA	in Crore	Net NPAs in current year	in Crore
Total Employees	Number	Total of Deposits	in Crore
Total of Borrowings	in Crore	Ratio of interest income to total assets	in %
Total of Investments (at book value)	in Crore	Ratio of net interest income to total assets (net interest margin)	in %
Total of Foreign Currency Assets	in Crore	Ratio of non-interest income to total assets	in %
Total of Loans and Advances	in Crore	Return on assets	in %
Cash - Deposit Ratio	in %	Return on equity	in %
Credit - Deposit Ratio	in %	Return on advances	in %
Investment - Deposit Ratio	in %	Return on investments	in %
Ratio of deposits to total liabilities	in %	Return on advances adjusted to cost of funds	in %
Ratio of demand & savings bank deposits to total deposits	in %	Return on investments adjusted to cost of funds	in %
Cost of deposits	in %	Business per employee	in Rupees Lakh
Cost of borrowings	in %	Profit per employee	in Rupees Lakh
Cost of funds	in %	Capital adequacy ratio	in %
Ratio of net NPA to net advances	in %	Net Profit	in Crore

As return on investments and return on advances are the most crucial variables to assess the performance of banking industry. Thus, these variables are considered as dependent variables (output) in regression models (Deb, 2019). Fixed assets, total assets, total employees, total deposits, total of foreign currency assets, ration of deposits ratio to total liabilities, ratio of demand & saving bank deposits to total deposits, ratio of non-interest income to total assets, return on equity and cost of fund are considered as inputs variables to examine the technical efficiency, and influence of these variables on return on investments and return on advances. Log-linear empirical models for return on investments and return on advances function are used in this study. Deb (2019) also used log-linear regression model to examine the technical efficiency affecting factors in Indian commercial banks. Following empirical model is used for return-on-investment function:

$$ln\ (RetInv)_{it} = \alpha_0 + \alpha_1\ ln\ (FixAss)_{it} + \alpha_2\ ln\ (TotAss)_{it} + \alpha_3\ ln\ (TotEmp)_{it} + \alpha_4\ ln\ (TotDep) + \alpha_5\ ln\ (TotForCurAss)_{it} + \alpha_6\ ln\ (RatDepTotLia)_i + \alpha_7\ ln\ (RatDemSavDep)_{it} + \alpha_8\ ln\ (RaNoInInToAss)_{it} + \alpha_9\ ln\ (RetEqu)_{it} + \alpha_{10}\ ln\ (CosFun)_{it} + \ + \alpha_{11}\ ln\ (logCaAdRa)_{it}\ (v_{it} - u_{it}) \quad (4)$$

Here, *ln* is natural logarithm of association variables; *RetInv* is return on investment; *i* is i^{th} banks (1, 2, 3, …., 47); *t* is time (2005 to 2020); α_0 is constant term; $\alpha_1, \alpha_2, \ldots, \alpha_{11}$ are regression coefficient of associated variables; and v_i and u_i are the error-term; and explanation of variables are given in Table 4. Following empirical model is used for return-on-investment function:

$$ln(RetAdv)_{it} = \beta_0 + \beta_1\ ln(FixAss)_{it} + \beta_2\ ln(TotAss)_{it} + \beta_3\ ln(TotEmp)_{it} + \beta_4\ ln(TotDep) + \beta_5\ ln(TotForCurAss)_{it} + \beta_6\ ln(RatDepTotLia)_{it} + \beta_7\ ln(RatDemSavDep)_{it} + \beta_8\ ln(RaNoInInToAss)_{it} + \beta_9\ ln(RetEqu)_{it} + \beta_{10}\ ln(CosFun)_{it} + \beta_{11}\ ln(logCaAdRa)_{it}\ (v_{it} - u_{it}) \quad (5)$$

Here, *RetAdv* is return on advances; is constant coefficient; $\beta_1, \beta_2, \ldots, \beta_{11}$ are the regression coefficient of corresponding variables in equation (5). Summary of remaining variables is given in Table 4.

Table 18.4: Summary of output and input variables

RetInv: Return on Investment
RetAdv: Return on advances
FixAss: Fixed Assets
TotAss: Total Assets
TotEmp: Total Employees
TotDep: Total of Deposits
TotForCurAss: Total of Foreign Currency Assets
RatDepTotLia: Ratio of deposits to total liabilities
RatDemSavDep: Ratio of demand & savings bank deposits to total deposits
RaNoInInToAss: Ratio of non-interest income to total assets
RetEqu: Return on equity
CosFun: Cost of funds
CaAdRa: Capital adequacy ratio

As this is also assess the technical efficiency of banking sector affecting factors. Therefore, technical efficiency of return on investment and return on advances are used as dependent variables. Following empirical model is used for technical efficiency of return-on-investment function:

$$(TE_RetInv)_{it} = €_0 + €_1 \ ln(FixAss)_{it} + €_2 \ ln(TotAss)_{it} + €_3 \ ln(TotEmp)_{it} + €_4 \ (TotDep)_{it} + €_5 \ ln(TotForCurAss)_{it} + €_6 \ ln(RatDepTotLia)_{it} + €_7 \ ln(RatDemSavDep)_{it} + €_8 \ ln(RaNoInInToAss)_{it} + €_9 \ ln(RetEqu)_{it} + €_{10} \ ln(CosFun)_{it} + €_{11} \ ln(CaAdRa)_{it} + €_{12} \ ln(PrPeEm)_{it} + €_{13} \ ln(RetAdv)_{it} + €_{14} \ ln(CosDep)_{it} + €_{15} \ ln(RatIntIncTotAss)_{it} + €_{16} \ ln(InvDepRat)_{it} + €_{17} \ ln(IntEarTot)_{it} + \varepsilon_{it} \quad (6)$$

Here, *TE_RetInv* is estimated technical efficiency of return-on-investment of i^{th} banks; $€_0$ is the constant coefficient; $€_1 \ldots €_{17}$ are the regression coefficients of related independent variables; and ε_{it} is error-error term in equation (6). The ln is natural logarithm and explanation of remaining variables is given in Table 5. Following empirical model is used for return-on-advances function:

$$(TE_RetAdv)_{it} = \theta_0 + \theta_1 \ ln(FixAss)_{it} + \theta_2 \ ln(TotAss)_{it} + \theta_3 \ ln(TotEmp)_{it} + \theta_4 \ (TotDep)_{it} + \theta_5 \ ln(TotForCurAss)_{it} + \theta_6 \ ln(RatDepTotLia)_{it} + \theta_7 \ ln(RatDemSavDep)_{it} + \theta_8 \ ln(RaNoInInToAss)_{it} + \theta_9 \ ln(RetEqu)_{it} + \theta_{10} \ ln(CosFun)_{it} + \theta_{11} \ ln(CaAdRa)_{it} + \theta_{12} \ ln(PrPeEm)_{it} + \theta_{13} \ ln(RetAdv)_{it} + \theta_{14} \ ln(CosDep)_{it} + \theta_{15} \ ln(RatIntIncTotAss)_{it} + \theta_{16} \ ln(InvDepRat)_{it} + \theta_{17} \ ln(IntEarTot)_{it} + \lambda_{it} \quad (7)$$

Here, *TE_RetAdv* is estimated technical efficiency of return on advances of i^{th} banks; θ_0 is the constant coefficient; $\theta_1 \ldots \theta_{17}$ are the regression coefficients of related independent variables; and λ_{it} is error-error term in equation (7).

Table 18.5: Technical efficiency of banking sector affecting variables

TE_RetInv: Technical efficiency of return on investment
TE_RetAdv: Technical efficiency of return on advances
FixAss: Fixed Assets
TotAss: Total Assets
TotEmp: Total Employees
TotDep: Total of Deposits
TotForCurAss: Total of Foreign Currency Assets
RatDepTotLia: Ratio of deposits to total liabilities
RatDemSavDep: Ratio of demand & savings bank deposits to total deposits

RaNoInInToAss: Ratio of net interest income to total assets (Net Interest Margin)
RetEqu: Return on equity
CosFun: Cost of funds
CaAdRa: Capital adequacy ratio
PrPeEm: Profit per employee
RetAdv: Return of advances
CosDep: Cost of deposits
RatIntIncTotAss: Ratio of interest income to total assets
InvDepRat: Investment - Deposit Ratio
IntEarTot: Interest Earned Total

18.4 RESULTS AND DISCUSSION

18.4.1 Association of Inputs with Return on Investment and Return on Advances

The regression coefficient of return on investment and return on advances with different input is presented in Table 6. The regression coefficient of selected variables with output are estimated using Time-varying decay model. Furthermore, technical efficiency if return-on-investment and return-on-advances of banks are also estimated under stochastic frontier production function model. The regression coefficient of return-on-investment with fixed assets, total deposits, total foreign currency assets, return-on-equity and cost of fund are seemed positive. Hence, the estimated indicate that banking sector must focus on aforementioned variables to increase the return-on-investment. The regression coefficient of return-on-advances with total employees, total deposits, ratio of non-interest income to total assets, return on equity and cost of funds are found positive and statistically significant. Accordingly, the estimates infer that return on advances for a bank will be improved as increase the role of abovementioned activities.

Table 18.6: Association of explanatory variables with performance of banks

	Return on Investment	**Return on Advances**
Number of obs	731	731
Number of groups	47	47
Wald chi2(11)	110.63	638.11
Prob > chi2	0.000	0.000

Log likelihood	235.71024			328.46285		
Variables	*Reg. Coef.*	*Std. Err.*	*P>|z|*	*Reg. Coef.*	*Std. Err.*	*P>|z|*
ln(*FixAss*)	0.01700	0.011	0.141	0.009	0.013	0.459
ln(*TotAss*)	-0.3962	0.126	0.002	-0.400	0.111	0.000
ln(*TotEmp*)	-0.0010	0.014	0.953	0.033	0.021	0.105
ln(*TotDep*)	0.3655	0.123	0.003	0.399	0.106	0.000
ln(*TotForCurAss*)	0.0111	0.007	0.095	-0.019	0.008	0.016
ln(*RatDepTotLia*)	-0.3793	0.133	0.004	-0.510	0.116	0.000
ln(*RatDemSavDep*)	0.0210	0.014	0.141	-0.024	0.018	0.183
ln(*RaNoInInToAss*)	0.0190	0.013	0.139	0.092	0.014	0.000
ln(*RetEqu*)	0.0289	0.009	0.001	0.036	0.008	0.000
ln(CosFun)	0.1098	0.020	0.000	0.409	0.020	0.000
ln(*CaAdRa*)	0.0250	0.024	0.307	0.033	0.024	0.179
Cons. Coef.	3.5523	0.631	0.000	3.825	0.567	0.000
/mu	-0.0720	0.351	0.837	0.270	0.095	0.004
/eta	0.0070	0.006	0.240	-0.003	0.011	0.765
/lnsigma2	-3.2310	0.469	0.000	-3.416	0.155	0.000
/ilgtgamma	-1.1760	1.980	0.553	-0.532	0.431	0.217
sigma2	0.040			0.033		
gamma	0.236			0.370		
sigma_u2	0.009			0.012		
sigma_v2	0.030			0.021		

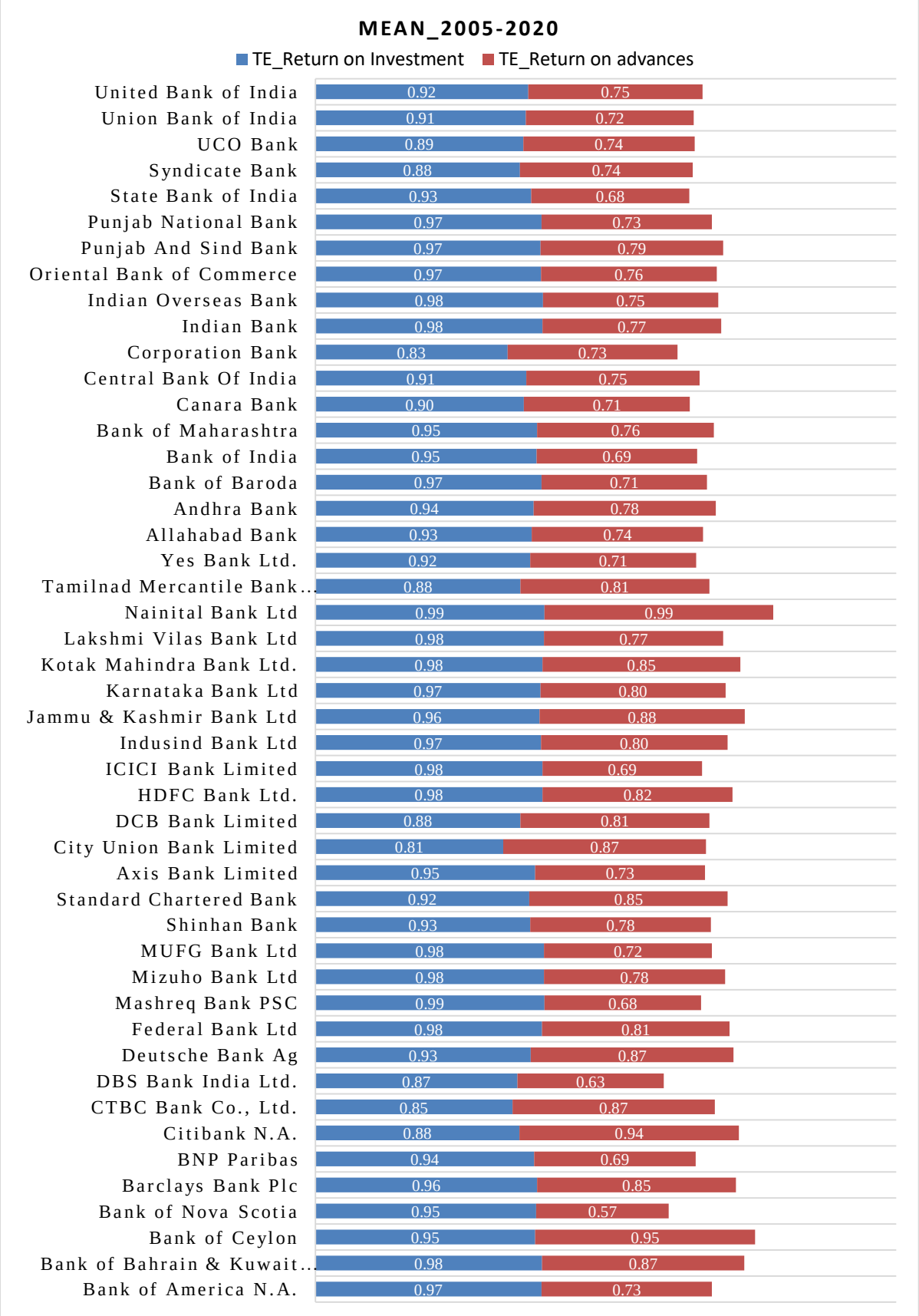
18.4.2 Technical Efficiency of Public, Private and Foreign Sector Banks

The mean value of technical efficiency of return on investment and return on advances of public sector, private and public sector banks is given in Figure 1. It is appeared that the mean values of technical efficiency for public sector banks varied between 0.83 to 0.98 during 2005 to 2020. Thus, the estimates indicate that there exists a high variation in technical efficiency among the public sector bank. Indian Overseas Banks and Indian bank have 0.98% technical efficiency for return on investment. Public sector banks have a large size in term of total assets; thus, these

banks have higher technical efficiency (Deb, 2019). Thus, these banks are efficient to get better return on investment. The technical efficiency is found 83%, 88% and 89% for Corporation Bank, Syndicate Bank and UCO banks respectively. Hence, these banks have potential to boost return on investment. As per estimates, public sector banks could not improve return on advances, as the technical efficiency for these banks are below 0.78%. Therefore, public sector banks have greater possibilities to improve return on advance through adopting a specific policy.

As per the estimated technical efficiency of return on investment for private sector, it is seemed that Nainital bank, Lakshmi Vilas Banks, HDFC Banks and ICICI Banks have highest technical efficiency (0.98%). Thus, here it can be concluded that these banks are able to maintain return on investment. City Union Bank, DCB banks and Tamilnad Mercantile Banks have lowest technical efficiency. Therefore, these banks could not improve technical efficiency, accordingly, there is greater scope to increase return on investment. The values of technical efficiency lie between 0.81 to 0.99%, thus, these banks have high diversity in technical efficiency. The results also show that Nainital Banks have highest efficiency (i.e., 99%) for return on advances. Other private sector banks have technical efficiency below 0.88% for return on advances. Therefore, it is suggested that all private sector banks are potential to increase return on advances.

Figure 18.1: Technical efficiency of public, private and foreign sector banks


MEAN_2005-2020
TE_Return on Investment
TE_Return on advances
United Bank of India 0.92 0.75
Union Bank of India 0.91 0.72
UCO Bank 0.89 0.74
Syndicate Bank 0.88 0.74
State Bank of India 0.93 0.68
Punjab National Bank 0.97 0.73
Punjab And Sind Bank 0.97 0.79
Oriental Bank of Commerce 0.97 0.76
Indian Overseas Bank 0.98 0.75
Indian Bank 0.98 0.77
Corporation Bank 0.83 0.73
Central Bank Of India 0.91 0.75
Canara Bank 0.90 0.71
Bank of Maharashtra 0.95 0.76
Bank of India 0.95 0.69
Bank of Baroda 0.97 0.71
Andhra Bank 0.94 0.78
Allahabad Bank 0.93 0.74
Yes Bank Ltd. 0.92 0.71
Tamilnad Mercantile Bank... 0.88 0.81
Nainital Bank Ltd 0.99 0.99
Lakshmi Vilas Bank Ltd 0.98 0.77
Kotak Mahindra Bank Ltd. 0.98 0.85
Karnataka Bank Ltd 0.97 0.80
Jammu & Kashmir Bank Ltd 0.96 0.88
Indusind Bank Ltd 0.97 0.80
ICICI Bank Limited 0.98 0.69
HDFC Bank Ltd. 0.98 0.82
DCB Bank Limited 0.88 0.81
City Union Bank Limited 0.81 0.87
Axis Bank Limited 0.95 0.73
Standard Chartered Bank 0.92 0.85
Shinhan Bank 0.93 0.78
MUFG Bank Ltd 0.98 0.72
Mizuho Bank Ltd 0.98 0.78
Mashreq Bank PSC 0.99 0.68
Federal Bank Ltd 0.98 0.81
Deutsche Bank Ag 0.93 0.87
DBS Bank India Ltd. 0.87 0.63
CTBC Bank Co., Ltd. 0.85 0.87
Citibank N.A. 0.88 0.94
BNP Paribas 0.94 0.69
Barclays Bank Plc 0.96 0.85
Bank of Nova Scotia 0.95 0.57
Bank of Ceylon 0.95 0.95
Bank of Bahrain & Kuwait... 0.98 0.87
Bank of America N.A. 0.97 0.73

The technical efficiency of return on investment for foreign sector banks lie between 0.85 to 0.99, thus, the estimates show that there is high variation in performance of foreign sector bank in India. Mshreq bank has highest technical efficiency (i.e., 99%) of return on investment. While, technical efficiency of MUFG Bank, MIZUHO bank, Bank of Bahrain & Kuwait B.S.C. are 0.98%, therefore, these banks have better efficiency to maintain return on investment. CTBC Bank have a lowest technical efficiency among the foreign sector banks in India. Technical efficiency of return on advances is found highest for Bank of Ceylon and lowest for Bank of Nova Scotia is seemed 0.57%. Most foreign banks have less than 0.87% technical efficiency, thus, these banks have potential to increase investment on advances.

18.4.3. Factors Affecting Technical Efficiency of Banks

The regression coefficient of technical efficiency of return on investment and return on advances of banks is given in Table 7. The regression coefficient of technical efficiency of return on investment of banks with fixed assets, ratio of demand & saving banks deposits to total deposits, ratio of net interest income to total assets, capital adequacy ratio, return on advances and Investment - Deposit Ratio are appeared positive and statistically significant. Hence, these variables are found most influencing factor of technical efficiency of investment on return of banks. Furthermore, the impact of total assets, total employees, ratio of deposits to total liabilities, cost of funds, profit per employee, cost of deposits, ratio of non-interest income to total assets and Interest Earned Total are seemed positive on return on investment of technical efficiency of banks in India. Deb (2019) also reported positive impact of total assets on efficiency of commercial bank in India. The technical efficiency of return on advances are positively associated with fixed assets, ratio of deposits to total liabilities, ratio of demand & savings bank deposits to total deposit and return on advances. Therefore, these variables are found most crucial factors to increase the technical efficiency of return on advances of banks in India. Some other variables such as total assets and total employees have a positive impact on technical efficiency of return on advances of banks in India. However, their regression

coefficients of these variables with technical efficiency of return on advances are not seemed statistically significant.

Table 18.7: Technical efficiency of banks affecting factors

	Return on Investment			**Return on advances**		
Number of obs.	710			730		
F – Value	3.91			50.96		
Prob > F	0.000			0.000		
R-squared	0.877			0.5489		
Adj. R-squared	0.833			0.5381		
Variables	*Reg. Coef.*	*Std. Err.*	*P>|t|*	*Reg. Coef.*	*Std. Err.*	*P>|t|*
ln(*FixAss*)	0.0092	0.0030	0.002	0.0056	0.00	0.090
ln(*TotAss*)	0.0235	0.0334	0.482	0.0330	0.04	0.390
ln(*TotEmp*)	0.0005	0.0059	0.939	0.0093	0.01	0.160
ln(*TotDep*)	-0.0270	0.0318	0.396	-0.0583	0.04	0.110
ln(*TotForCurAss*)	-0.0035	0.0017	0.043	-0.0006	0.00	0.740
ln(*RatDepTotLia*)	0.0179	0.0353	0.611	0.0827	0.04	0.040
ln(*RatDemSavDep*)	0.0074	0.0038	0.049	0.0401	0.00	0.000
ln(*RaNoInInToAss*)	0.0067	0.0036	0.064	-0.0213	0.00	0.000
ln(*RetEqu*)	-0.0035	0.0043	0.415	-0.0184	0.00	0.000
ln(*CosFun)*	0.0087	0.0097	0.373	-0.0150	0.01	0.160
ln(*CaAdRa*)	0.0133	0.0066	0.045	-0.0113	0.01	0.130
ln(*PrPeEm*)	0.0034	0.0043	0.435	0.0173	0.00	0.000
ln(*RetAdv*)	-0.0292	0.0125	0.019	0.2701	0.01	0.000
ln(*CosDep*)	0.0001	0.0040	0.986	-0.0084	0.00	0.060
ln(*RatIntIncTotAss*)	0.0071	0.0163	0.664	-0.1301	0.02	0.000
ln(*InvDepRat*)	0.0127	0.0069	0.066	-0.0288	0.01	0.000
ln(*IntEarTot*)	0.0014	0.0054	0.794	-0.0061	0.01	0.310
Cons. Coef.	0.7754	0.1781	0	0.3264	0.20	0.110

18.5 CONCLUSION AND POLICY IMPLICATIONS

The main aim of this study is to estimate the technical efficiency of 18-public sector, 16-foreign sector and 13-private sector banks in India during 2005 – 2020. It used log-linear regression model under stochastic production function approach. Thereupon, it examines the technical efficiency affecting factors using panel data during 2005 – 2020. Return on investment and return on advances are considered as outputs in order to estimate the technical efficiency of banks. The regression coefficient of return-on-investment with fixed assets, total deposits, total foreign currency assets, return-on-equity and cost of fund are seemed positive and statistically significant. The regression coefficient of return-on-advances with total employees, total deposits, ratio of non-interest income to total assets, return on equity and cost of funds are found positive and statistically significant. Hence, aforesaid variables are effective to increase the performance of public, private and foreign sector banks in India.

The estimates indicate that there exists a high variation in technical efficiency among the public sector bank. Indian Overseas Banks and Indian bank have 0.98% technical efficiency for return on investment. Thus, these banks are efficient to get better return on investment. The technical efficiency is found 83%, 88% and 89% for Corporation Bank, Syndicate Bank and UCO banks respectively. Hence, these banks have potential to boost return on investment. As the technical efficiency of return on advances for public sector banks are below 0.78%. Thus, public sector banks have greater possibilities to improve return on advance through adopting a specific policy. Nainital bank, Lakshmi Vilas Banks, HDFC Banks and ICICI Banks have highest technical efficiency (0.98%) among the private sector banks. City Union Bank, DCB banks and Tamilnad Mercantile Banks have lowest technical efficiency. Other private sector banks have technical efficiency below 0.88% for return on advances. Therefore, it is suggested that all private sector banks are potential to increase return on advances. The technical efficiency of return on investment for foreign sector banks lie between 0.85 to 0.99, thus, the estimates show that there is high variation in performance of foreign sector banks. Technical efficiency of MUFG Bank, MIZUHO bank, Bank of Bahrain & Kuwait B.S.C. are 0.98%, therefore, these banks have better efficiency to maintain return on investment. CTBC Bank have a lowest technical efficiency among the foreign sector banks. Moreover, technical efficiency of return on advances is found

highest for Bank of Ceylon and lowest for Bank of Nova Scotia is seemed 0.57%. Most foreign banks have less than 0.87% technical efficiency, thus, these banks have potential to increase investment on advances.

Fixed assets, ratio of demand & saving banks deposits to total deposits, ratio of net interest income to total assets, capital adequacy ratio, return on advances and Investment - Deposit Ratio are found most influencing factor of technical efficiency of investment on return of banks. Fixed assets, ratio of deposits to total liabilities and ratio of demand & savings bank deposits to total deposit found most crucial factors to increase the technical efficiency of return on advances of banks in India. As Indian public sector banks provide the financial facilities most citizens of India, thus, Indian government should give more priority to increase the technical efficiency of public sector banks in India. There is essential to monitor the performance of those banks which have lower technical efficiency by Reserve Bank of India (Singh and Malik, 2018). It would be useful to increase the performance of banking sector in India.

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